REMARKS

Applicant thanks the Examiner for acknowledging their claim to priority under 35 U.S.C. § 119, and receipt of a certified copy of the priority document. However, for the sake of clarifying the record in this case, Applicant note that the present application was filed as a result of entry into national stage proceedings of a prior PCT application, Application No. PCT/GB99/03076. Accordingly, copies of the certified copy of the priority document would have been received from the International Bureau.

Claims 1-26 are all the claims pending in the application, claims 13-26 having been added to claim the disclosed invention more completely.

Claims 1-3 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Okamoto (USP 5,049,739) in view of Micromass (EP 0 813 228) and further in view of Javahery (USP 6,093,929). Applicants have amended independent claim 1 to more accurately recite the invention.

Claims 4-12 are objected to under 37 CFR § 1.75(c) as being multiple dependent claims depending from multiple dependent claims. In response, Applicants have amended preambles of claims 4-6 and 8-12.

Applicants have also added claims 13-26 to recite a method of operating an ICP mass spectrometer.

Applicants respectfully request allowance of claims 1-6 and 8-26 in view of the following arguments.

Amended claim 1 explicitly recites that the first ion optical device 17 is a mass selective device, that the ion beam is mass filtered before the collision cell, and that both the first ion optical device 17 and the mass-to-charge ratio analyzing means 37 operate at the same mass to charge ratio. Applicants assert that claim 1 and its dependencies are patentable over the prior art of record.

1. The Present Application

The claimed invention provides a mass spectrometer in which unwanted artefact ions are selectively removed from an ion beam by reacting with a reagent gas. Looking at the figures in the present application, the first ion optical device 17 (Fig. 2) is a mass selective device, and can be driven to transmit only ions of a specific mass to charge ratio (m/e) or a range of m/e. As such, this device functions as an auxiliary mass filter. The first ion optical device 17 can first reduce the contribution of artefact ions to the mass spectrum, since it is set to transmit only ions from the same m/e as the main mass filter. The artefact ion must have a different m/e from that selected, and so will not be transmitted by the main mass filter. Hence the mass spectrum is essentially free from artefact ions (see specification, page 8, lines 9-27).

The mass filtered ion beam is then transmitted into the collision cell 24, which is a chamber pressurized with target gas 26. The purpose of the collision cell is to alter the artefact ions which will interfere with the detection of the analyte ions, e.g., $^{40}Ar^{16}O$ interfering with

detection of ^{56}Fe. The collisions between the artefact ions and the target gas induce reactions which result in ions of a different mass to charge ratio which will not interfere with detection of the analyte ions in the mass analysis stage (page 8, lines 27-36).

The advantage of the pre-collision mass filtering of the present application is that it removes any ions from the beam which might cause formation of new artifact ions in the collision cell. The reactions induced by the collisions can be charge exchange reactions, fragmentation or formation of new ions, e.g., by reaction with a reactive target gas such as hydrogen.

Looking again at Fig. 2 of the present application, on exiting the collision cell 24, the ion beam passes through aperture 32 into evacuated chamber 33 which contains a mass analyzer 37 (page 10, lines 26-30). The mass analyzer 37 analyses the ion beam to produce a mass spectrum of the ion beam, operating at the same mass to charge ratio as the first ion optical device 17. Thus, in the present application, the mass analysis after the collision cell is carried out at the same mass to charge ratio as the pre-collision cell filtering step, i.e., at the analyte mass to charge ratio, thereby rejecting ions generated from the artefact ions by the collisions.

2. Okamoto

Okamoto provides a plasma ion source mass spectrometer for trace elements. As shown in Fig. 3 of Okamoto, the plasma generating section makes plasma 70 absorb microwave power by means of a coaxial helical coil 21. The center part of plasma 70 is diffused into a moderate pressure region through an orifice 81 formed in a plasma sampling electrode 80 to produce a diffused plasma 71. The diffused plasma 71 then passes through an orifice 91 of an ion extraction electrode 90, and an orifice 101 of an ion acceleration electrode 100. An ion sheath is

formed in the neighborhood of the orifice 91 and ions are extracted from the diffused plasma 71 and form an ion beam 200. The ion beam 200 is converged by the ion lens system 110 and introduced into the charge exchange reaction cell 120 (Okamoto, col. 3, lines 34-65).

Clearly, Okamoto does not teach or suggest mass selection. Neither does Okamoto teach or suggest pre-collision mass filtering, or the mass-to-charge ratio analyzing means 37 operating at the same mass to charge ratio as the first ion optical device 17 recited in the apparatus claims of the present application.

3. Micromass

In Fig. 1 of Micromass, a plasma torch 1 generates a plasma 2. Ions pass from the plasma 2 into an evacuated region 8 through a cone 3 and a skimmer 5, and then into a first evacuated chamber 11 through an aperture in an electrostatic lens element 10. Ions next travel through ion guiding means 12 disposed in the first evacuated chamber 11.

In Fig. 3 of Micromass, a conventional quadrupole mass analyzer comprising a quadrupole mass filter 29 and an ion detector 33 is disposed in the second evacuated chamber 20. Ions leaving the exit of the ion guiding means 12 are deflected in a field generated by a suitable potential applied to the tapered electrode 18, so that they pass along the entrance axis 32 of the filter 29.

Apparently, the only possible structure in Micromass that might correspond to the first ion optical device 17 in the present application is the ion guiding means 12, which is not mass selective. Thus, Micromass does not teach a first ion optical device which is a mass selective device. Neither does Micromass teach or suggest pre-collision mass filtering, or mass to charge

ratio analyzing means 37 operating at the same mass to charge ratio as the first ion optical device 17 recited in the apparatus claims of the present application.

4. Jahavery

In Jahavery, ions are mass selected before entry to the collision cell at a mass corresponding to the analyte ions. At this stage, the analyte ions will be ionised large organic molecules. The purpose of the collision cell is to fragment these large organic parent ions into daughter fragments consisting of small parts of the original large organic ion. The mass analysis step then detects these daughter ions emerging from the collision cell. Thus, the mass filtering and the mass analysis steps are carried out at different mass to charge ratios, as distinguished from the present application, per the foregoing discussion.

For the foregoing reasons, Applicant submits that claims 1-6 and 8-12 are patentable.

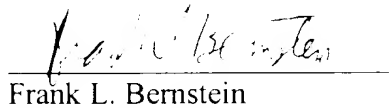
Newly added independent claim 13 is directed to a method of operating an ICP mass spectrometer. Claim 13 explicitly recites the step of mass analyzing the ion beam at the same analyte mass to charge ratio as mass selecting. As discussed above, none of the cited references teach or suggest this recited feature. Therefore, claim 13 and its dependent claims 14-26 are patentable.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue

Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,



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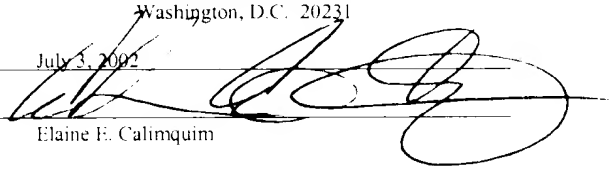
Signed: 

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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

The claims are amended as follows:

1. (As amended) A mass spectrometer comprising:

means (1) for generating ions from a sample introduced into a plasma;

a sampling aperture (2) for transmitting some of the ions into an evacuated expansion chamber (3) along a first axis (9) to form an ion beam;

a second aperture (5) for transmitting some of the ion beam into a first evacuated chamber (6);

a first pump (7) for maintaining the first evacuated chamber (6) at high vacuum;

a first ion optical device (17) located in the first evacuated chamber (6) for containing the ion beam wherein the first ion optical device (17) is a mass selective device;

a third aperture (19) for transmitting the ion beam into a second evacuated chamber (20);

a second pump (21) for maintaining the second evacuated chamber (20) at a lower pressure than the first evacuated chamber (6);

a collision cell (24) having an entrance aperture (27) and an exit aperture (28) and pressurized with a target gas (26), the collision cell (24) being disposed in the second evacuated chamber (20);

a second ion optical device (25) located in the collision cell (24) for containing the ion beam;

a fourth aperture (32) for transmitting the ion beam into a third evacuated chamber (33) containing mass-to-charge ratio analyzing means (37) disposed along a second axis (36) for mass analyzing the ion beam to produce a mass spectrum of the ion beam such that both the first ion optical device (17) and the mass-to-charge ratio analyzing means (37) operate at the same mass to charge ratio;

a third pump (39) for maintaining the third evacuated chamber (33) at lower pressure than the second evacuated chamber (20).

3. (As amended) A mass spectrometer according to claim 1 [or 2], wherein the first evacuated chamber (6) is maintained at a pressure of approximately 1-2 x 10^{-3} mbar.

4. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, including a gap of at least 2 cm between the third aperture (19) and the entrance aperture (27) of the collision cell (24).

5. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the distance between the ion source (1) and the entrance aperture (27) of the collision cell (24) is 90 to 200 mm.

6. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the mass-to-charge ratio analyzing means (37) includes a main mass filter which preferably is an RF quadrupole.

Cancel Claim 7

8. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the first ion optical device (17) is an RF quadrupole.

9. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the second ion optical device (25) is an RF quadrupole.

10. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the second ion optical device (25) is mass selective.

11. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the second axis (36) of the mass to charge ratio analyzing means (37) is offset from the first axis (9).

12. (As amended) A mass spectrometer according to [any one of the preceding claims] claim 1, wherein the first evacuated chamber (6) is divided into a first region (14) adjacent to the expansion chamber containing an extractor lens (8) driven at a negative potential, and a second region (15) adjacent to the collision cell (24) in which the ion optical device (17) is located, by a large diameter aperture (11) and the aperture is sealable by means of a flat plate (12) on an O-ring seal (13).

Claims 13 - 26 are added as new claims.

13. A method of operating an ICP mass spectrometer that incorporates a collision cell pressurized with a target gas, comprising the steps of:

generating, from an ion source, an ion beam including analyte ions and artefact ions;

mass selecting the ion beam at an analyte mass to charge ratio;

transmitting the ion beam into the collision cell;

inducing collisions between the artefact ions and the target gas in the collision cell; and

mass analyzing the beam at the analyte mass to charge ratio.

14. A method according to claim 13, wherein the mass selecting is achieved by passing the ion beam through a first mass selective ion optical device.

15. A method according to claim 14, further comprising locating the first mass selective ion optical device in a first evacuated chamber maintained at high vacuum.

16. A method according to claim 15, further comprising locating the collision cell in a second evacuated chamber operated at lower pressure than the first evacuated chamber,

the ion beam being contained in the second evacuated chamber by a second ion optical device.

17. A method according to claim 15, wherein the first evacuated chamber is maintained at a pressure of approximately 10^{-2} to 10^{-4} mbar.

18. A method according to claim 15, wherein the first evacuated chamber is maintained at a pressure of approximately 1-2 x 10^{-3} mbar.

19. A method according to claim 16, wherein the ion beam, resulting from transmitting some of the ions from the ion source through a sampling aperture into an evacuated expansion chamber along a first axis, is transmitted into the first evacuated chamber through a second aperture, and into the second evacuated chamber through a third aperture, and wherein a gap of at least 2 cm is maintained between the third aperture and an entrance aperture of the collision cell.

20. A method according to claim 13, wherein a distance of 90 to 200 cm is maintained between the ion source and an entrance aperture of the collision cell.

21. A method according to claim 19, further comprising locating a mass-to-charge ratio analyzing means in a third evacuated chamber operated at lower pressure than the second evacuated chamber and disposing the mass-to-charge ratio analyzing means along a second axis, wherein the mass-to-charge ratio analyzing means includes a main mass filter which preferably is an RF quadrupole.

22. A method according to claim 14, wherein the first mass selective ion optical device is an RF quadrupole.

23. A method according to claim 16, wherein the second ion optical device is an RF quadrupole.

24. A method according to claim 16, wherein the second ion optical device is mass selective.

25. A method according to claim 15, wherein the first evacuated chamber is divided into a first region adjacent to the expansion chamber containing an extractor lens driven at a negative potential, and a second region adjacent to the collision cell, by a large diameter aperture and the aperture is sealable by means of a flat plate on an O-ring seal.

26. A method according to claim 21, wherein the second axis is offset from the first axis.